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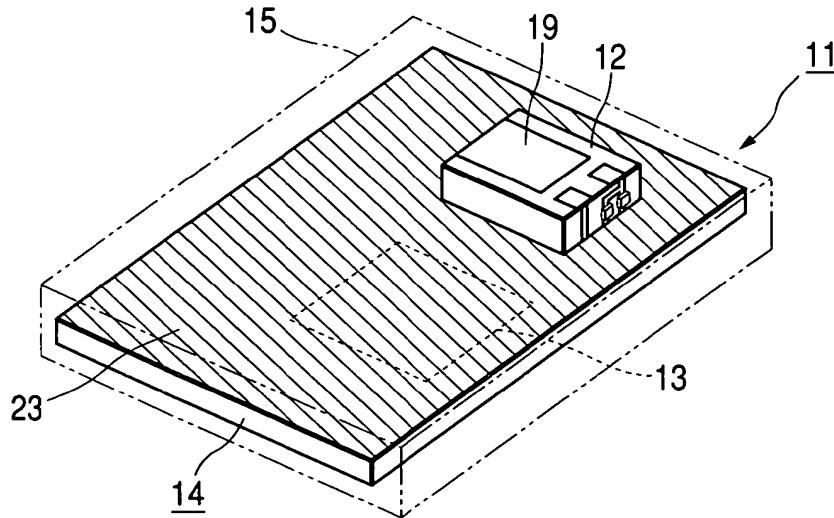
### (54) Card with built-in antenna

(57) The present invention relates to a card with a built-in antenna in which the resonant frequency of the antenna can be effectively changed in response to the received frequency. Also, the present invention relates to the card with a built-in antenna which is detachable to electronic apparatuses such as a portable information terminal comprising a display screen.

The card with a built-in antenna 11 is a reception apparatus for digital terrestrial television (DTTV) broadcasting and is mounted on a portable information terminal 1 comprising a liquid crystal display unit 2. In the

card 11, an antenna element 12 and a tuner 13 are mounted on a circuit board 14 inside an enclosing case 15, and a varactor diode 16 (variable capacitor element), a resistor 17, etc are laid on the side of the antenna element 12. The antenna element 12 is an inverted F-type dielectric antenna for example, and can change the resonant frequency of the antenna in response to the received frequency by applying a DC bias voltage from a tuner 13 to the varactor diode 16 and effectively changing the capacitance of the varactor diode 16.

## FIG. 1



**Description****BACKGROUND OF THE INVENTION****1. Field of the Invention**

**[0001]** The present invention relates to a card with a built-in antenna which is used being mounted on an electronic apparatus comprising a display screen, in particular, to the card with a built-in antenna suitable for mounting on a portable information terminal capable of receiving digital terrestrial television (DTTV) broadcasting.

**2. Description of the Related Art**

**[0002]** In general, conventional retractable rod antennas, are used as the antenna device used in portable television receivers, because the rod antennas with the length of tens centimeters are suitable for receiving the frequency in VHF band. But a user must adjust the sensitivity of the rod antenna by modifying the length of the antenna or changing its angle or direction in response to the received channel (received frequency) in order to obtain the optimal reception sensitivity of the rod antennas. Also, the rod antennas have the problem that it has a burdensome projection and easily broken because they must be extended to use.

**[0003]** However, in digital terrestrial television broadcasting that is soon to be introduced, a short rod antenna or a built-in antenna can be used because the lowest frequency to be received is set to 470 MHz of UHF band. In particular, the built-in antenna can change easily the antenna resonant frequency by using a variable coil, so thus it does not need vexatious sensitivity adjustment and it may be used conveniently. Conventional techniques propose that this kind of built-in antenna be assembled inside a portable television receiver. The techniques are referred to patent document 1 (the page 5 and Fig. 6 of Japanese Patent Application Publication No. 2001-339329), for example.

**[0004]** However, in digital terrestrial television broadcasting in which the length of the antenna can be comparatively short, the reception is intended for portable information terminals such as PDAs (Personal Digital Assistants) and cellular phones as well as dedicated television receivers. In those cases, it can be assumed that the antenna, tuner, and etc. for receiving digital terrestrial television broadcasting are provided inside the body of the apparatus such as PDAs and cellular phones in advance. But if the antenna and tuner are assembled into the card detachably mounted to the body of the apparatus to form a card with a built-in antenna. The size or weight of the apparatus can be reduced without reducing the size of the display screen. Also, the apparatus can be used for another purpose by attaching another card with a built-in antenna to the apparatus. Thus, this built-in antenna card adds value because it pro-

motes the multi-functionality of the apparatus. However, in order to ensure good television broadcasting reception with a small antenna, the circuit that effectively changes the resonant frequency of the antenna in response to the received frequency is required. The card with a built-in antenna comprising said circuit has not yet been proposed.

**SUMMARY OF THE INVENTION**

**[0005]** This invention was made in consideration of the aforementioned problems of conventional techniques, and the object of the present invention is to provide a card with a built-in antenna in which the resonant frequency of the antenna can be effectively changed in response to the received frequency, and can be detachable to electronic apparatuses such as portable information terminals comprising a display screen.

**[0006]** In order to achieve the above objects, the invention provides a card with a built-in antenna which is detachably mounted on a electronic apparatus comprising a display screen capable of displaying image based on a received radio signal, and the card with a built-in antenna comprises an antenna element protruding from the electronic apparatus to outside in a mounted state; tuning control means for changing the resonant frequency of the antenna element in response to a received frequency; and a tuner to which the received signal of antenna element is input.

**[0007]** As such, in the card with a built-in antenna comprising the tuning control means for changing the resonant frequency of the antenna element in response to a received frequency, the antenna element can be smaller and still have the good reception sensitivity.

**[0008]** In the above card with a built-in antenna, it is preferable that a variable capacitor element such as a varactor diode be used as the tuning control means. So thus, it is possible to realize the tuning control for changing the resonant frequency of the antenna element in response to a received frequency with simple construction. It is possible to effectively change the additional capacitance of variable capacitor element by applying the DC bias voltage from the tuner in order to change the additional capacitance of the antenna element.

**[0009]** In the above card with a built-in antenna, when the antenna element is a dielectric antenna in which a radiating electrode is laid on the surface of a dielectric substrate, the size of the antenna element can be reduced, the stable performance of the antenna can be obtained, and the assembly performance improve because the modularized antenna element can be mounted easily.

**[0010]** Furthermore, in the above card with a built-in antenna, it is preferable that the received frequency be within UHF band, and the tuner receive television signal.

This invention is highly useful as the card with a built-in antenna for receiving digital terrestrial television broadcasting in which the lowest frequency to be received is set to 470 MHz. In this case, the portable information terminal which can at least be used as a television receiver is suitable for the electronic apparatus to mount the above card with a built-in antenna thereon.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### [0011]

Fig. 1 is a schematic structure diagram of the card with a built-in antenna according to the first embodiment of the present invention.

Fig. 2 is a view for illustrating the card illustrated in Fig. 1 mounted on a portable information terminal.

Fig. 3 is a perspective view of an antenna element embedded in the card illustrated in Fig. 1.

Fig. 4 is a bottom view of the antenna element illustrated in Fig. 3.

Fig. 5 is a schematic structure diagram of the card with a built-in antenna according to the second embodiment of the present invention.

Fig. 6 is a perspective view of an antenna element embedded in the card illustrated in Fig. 5.

Fig. 7 is a bottom view of the antenna element illustrated in Fig. 6.

Fig. 8 is a schematic structure diagram of the card with a built-in antenna according to the third embodiment of the present invention.

Fig. 9 is a perspective view of an antenna element embedded in the card illustrated in Fig. 8.

Fig. 10 is a bottom view of the antenna element illustrated in Fig. 9.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] The preferred embodiments of the invention will now be described with reference to the accompanying drawings. Fig. 1 is a schematic structure diagram of the card with a built-in antenna according to the first embodiment of the present invention. Fig. 2 is a view for illustrating said card mounted on a portable information terminal. Fig. 3 is a perspective view of an antenna element embedded in said card. Fig. 4 is a bottom view of the antenna element illustrated in Fig. 3.

[0013] The card with a built-in antenna 11 illustrated in Fig. 1 is a card type electronic device for receiving the signal wave (horizontally polarized wave) of digital terrestrial television broadcasting whose frequency is between 470 MHz and 770 MHz. The card 11 is mounted on the portable information terminal 1 of Fig. 2. The card 11 comprises a circuit board 14 on which an antenna element 12 and a tuner 13 are mounted and which is accommodated in an enclosing case 15. A varactor diode 16 and a resistor 17 are laid on the side of the antenna element 12 (Refer to Fig. 3).

[0014] The antenna element 12 is an inverted F-type dielectric antenna in which a radiating electrode 19, a earth electrode 20, a feed terminal 21, a control terminal 22, etc are laid on the surface of a rectangular parallelepiped dielectric substrate 18. The dielectric substrate 18 is made of the dielectric material such as ceramics, resins, etc. The electrodes 19, 20 and the terminals 21, 22 are made of a conductive layer such as a copper film, respectively. On the top surface of the dielectric substrate 18, the radiating electrode 19 has capacitor coupling units C1, C2 at two positions and matches impedance or adjusts additional capacitance by these capacitor coupling units C1, C2. On the bottom surface of the dielectric substrate 18, the earth electrode 20 is connected to a ground conductor 23 on the side of the circuit board 14, and the feed terminal 21 and the control terminal 22 are connected to the tuner 13. A high frequency feed voltage is supplied to the feed terminal 21, and a DC bias voltage (control voltage) is applied to the control terminal 22.

[0015] The varactor diode 16 is a variable capacitor element whose capacitance changes in response to the applied DC bias voltage. One pole of the varactor diode 16 is connected to the resistor 17, and the other pole is connected to the earth electrode 20. The resistor 17 for deterring high frequency is connected to the control terminal 22. The DC bias voltage is applied to the varactor diode 16 through the resistor 17. The radiating electrode 19 is not affected by the DC bias voltage, because the DC bias voltage is cut off by the capacitor coupling unit C2.

[0016] The tuner 13 is a tuner for receiving a television signal. The signal (RF signal) received from the antenna element 12 is input to the tuner 13. The tuner 13 processes the input signal and outputs this signal as an IF signal to the liquid crystal display unit 2 of the portable information terminal 1.

[0017] The portable information terminal 1 comprises a slot 3 for detachably mounting the card with a built-in antenna 11 therein. As shown in Fig. 2, when the card with a built-in antenna 11 is mounted on the portable information terminal 1, the antenna element 12 mounted on one side of the card 11 protrudes from the portable information terminal 1 to outside. When an image is displayed on the liquid crystal display unit 2 by receiving the digital terrestrial television broadcasting, the card 11 is mounted on the portable information terminal 1 as shown in Fig. 2, and the antenna element 12 operate as the an inverted F-type antenna for receiving broadcasting. In case the reception of the terrestrial television broadcasting is terminated or the portable information terminal 1 is used for another purpose by mounting another card therein, the card with a built-in antenna 11 is taken out from the slot 3.

[0018] The operation of the antenna element 12 will be described in detail. The resonant frequency of the antenna can be changed in response to the amplitude of the DC bias voltage (control voltage) applied to the

varactor diode 16, because the additional capacitance of the antenna element 12 effectively changes in response to the capacitance of varactor diode 16 (variable capacitor element). That is, the resonant frequency of the antenna element can be tuning-controlled in response to a received frequency, because the additional capacitance of the antenna element 12 can be effectively changed by applying the DC bias voltage from the tuner 13 to the varactor diode 16 in order to change the capacitance of the varactor diode 16. Thus, the image signal received by the antenna element 12 can be processed by the tuner 13 and be displayed on the liquid crystal display unit 2 of the portable information terminal 1 by synchronizing the resonant frequency of the antenna element with the received frequency.

**[0019]** As such, the card with a built-in antenna 11 according to the first embodiment can obtain good reception sensitivity by the antenna element 12 with small size, because it comprises the varactor diode 16 for changing the resonant frequency of the antenna element in response to a received frequency. Also, this invention enables the entire card 11 to be compact in size while securing the space occupied by the antenna element 12, the tuner 13, etc. Further, this invention does a credible job of tuning control of the resonant frequency of the antenna element with a simple construction, because the method of controlling the capacitance of the varactor diode 16 is very simple.

**[0020]** In the card with a built-in antenna 11 according to the first embodiment, the antenna element 12 is a dielectric antenna. Thus, the size of the antenna element 12 can be easily reduced and the stable performance of the antenna element can be obtained. Also, the modularized antenna element 12 can be accurately and easily mounted on the circuit board 14. Further, the good reception sensitivity can be expected even in a room where the jitter of a polarized wave may occur with ease, because this antenna element 12 is an inverted F-type antenna which can receive both a vertically polarized wave and a horizontally polarized wave.

**[0021]** In the first embodiment, although the varactor diode 16 is attached to the antenna element 12 as the variable capacitor element, the variable capacitor element may be directly mounted on the circuit board 14. Also, although the feed terminal 21 and the control terminal 22 are respectively provided in the antenna element 12 in the first embodiment, a feed voltage and a DC bias voltage (control voltage) from the tuner 13 may be superposed and supplied to one terminal provided in the antenna element 12.

**[0022]** Fig. 5 is a schematic structure diagram of the card with a built-in antenna according to the second embodiment of the present invention. Fig. 6 is a perspective view of an antenna element embedded in said card. Fig. 7 is a bottom view of the antenna element illustrated in Fig. 6. In the Fig. 5 to Fig. 7, the same reference numerals refer to the same parts as Fig. 1 to Fig. 4.

**[0023]** The card with a built-in antenna 31 illustrated

in Fig. 5 differs from the first embodiment in that the card 31 comprises a loop type antenna element 32. That is, the antenna element 32 shown in Fig. 5 to Fig. 7 is a loop type dielectric antenna comprising a band radiating electrode 19 formed along the side surface of a rectangular parallelepiped dielectric substrate 18. A capacitor 24 is interposed between the radiating electrode 19 and the feed terminal 21. The feed terminal 21, a control terminal 22 and an earth terminal 25 are provided on one end side of the bottom surface of the dielectric substrate 18.

The feed terminal 21 and the control terminal 22 are connected to the tuner 13, and the earth terminal 25 is connected to the ground conductor 23 on the side of the circuit board 14. One pole of the varactor diode 16 is connected to the resistor 17, and the other pole is connected to the earth terminal 25 through the radiating electrode 19. The resistor 17 for deterring high frequency is connected to the control terminal 22. The DC bias voltage (control voltage) is applied to the varactor diode 16 through the resistor 17. As shown in Fig. 5, the ground conductor 23 is absent from the area of the circuit board 14 occupied by the antenna element 32 and the periphery thereof in the side of the circuit board 14, but the basic construction is same as that of the first embodiment.

**[0024]** As such, in the card with a built-in antenna 31 according to the second embodiment, the radiating pattern of the horizontally polarized wave is non-directional because a loop type antenna is used as the antenna element 32. Thus, even if the portable information terminal comprising the card with a built-in antenna 31 facing any direction, it can receive the digital terrestrial television broadcasting signal with the same reception sensitivity. Also, if the loop type antenna element 32 is used, it is hard for the antenna element 32 to be affected by a human body.

**[0025]** Fig. 8 is a schematic structure diagram of the card with a built-in antenna according to the third embodiment of the present invention. Fig. 9 is a perspective view of an antenna element embedded in the card. Fig. 10 is a bottom view of the antenna element illustrated in Fig. 9. In the Fig. 8 to Fig. 10, the same reference numerals refer to the same parts as Fig. 5 to Fig. 7.

**[0026]** The antenna element 42 of the card with a built-in antenna 41 illustrated in Fig. 8 is a slightly different loop type antenna from that of the second embodiment. In the antenna element 42 of Fig. 8 to Fig. 10, a long thin radiating electrode 19 is spirally laid along the side surface of the rectangular parallelepiped dielectric substrate 18. Also, the varactor diode 16 and the resistor 17 mounted on the top surface of the dielectric substrate 18 are respectively connected to the feed terminal 21 and the control terminal 22 through via holes 26, 27 that penetrate the dielectric substrate 18. Since one end of the radiating electrode 19 which is spirally extended is connected to the varactor diode 16 on the top surface of the dielectric substrate 18, it is also connected to the feed terminal 21 through the via hole 26. Further, the

other end of the radiating electrode 19 is connected to the earth terminal 25 on the bottom surface of the dielectric substrate 18. Also, the basic construction of the circuit board 14 is same as that of the second embodiment.

**[0027]** As such, in the card with a built-in antenna 41 according to the third embodiment, it is possible to lengthen the antenna without enlarging the dielectric substrate 18, because the radiating electrode 19 of the antenna element 42 is spirally laid. Thus, the small antenna can receive a signal with a long wavelength. Also, like the second embodiment, the radiating pattern of the horizontally polarized wave is non-directional because the antenna element 42 is a loop type antenna. Thus, even if the portable information terminal faces any direction, it can receive the digital terrestrial television broadcasting signal with the same reception sensitivity. Also, it is hard for the antenna element 42 to be affected by a human body.

**[0028]** In the second and third embodiments, although the varactor diode 16 is attached to the antenna element 32 (42) as the variable capacitor element, the variable capacitor element may be directly mounted on the circuit board 14. Also, although the feed terminal 21 and the control terminal 22 are respectively provided on the antenna element 32 (42) in the second and third embodiments, a feed voltage and a DC bias voltage (control voltage) from the tuner 13 may be superposed and supplied to one terminal provided on the antenna element 32 (42).

**[0029]** The present invention according to the aforementioned embodiments has effects as follows.

**[0030]** The present invention relates to the card with a built-in antenna comprising the tuning control means for changing the resonant frequency of the antenna element in response to a received frequency and enables the small antenna element with the good reception sensitivity. Thus, the present invention enables the entire card to be compact in size while securing the space occupied by tuner, etc. Hence, if the card with a built-in antenna is detachably mounted on a portable information terminal comprising a display screen, it is very useful as the card with a built-in antenna for receiving digital terrestrial television broadcasting.

**[0031]** Further, if the variable capacitor element such as a varactor diode is used as the tuning control means, the additional capacitance of the antenna element can be effectively changed by applying the DC bias voltage from the tuner to the variable capacitor element in order to change the capacitance thereof. Thus, the present invention can realize a tuning control for changing the resonant frequency of the antenna element in response to a received frequency with simple configuration.

**[0032]** While the present invention has been described in particular embodiments, it should be appreciated that the present invention should not be construed as limited by such embodiments, but rather construed according to the following claims.

## Claims

5      1. A card with a built-in antenna which is detachably mounted on a electronic apparatus comprising a display screen capable of displaying image based on a received radio signal, comprising:

10     an antenna element protruding from the electronic apparatus to outside in a mounted state; tuning control means for changing the resonant frequency of the antenna element in response to a received frequency; and a tuner to which the received signal of antenna element is input.

15     2. The card with a built-in antenna of claim 1, wherein a variable capacitor element is used as the tuning control means.

20     3. The card with a built-in antenna of claim 1 or 2, wherein the antenna element is a dielectric antenna in which a radiating electrode is laid on the surface of a dielectric substrate.

25     4. The card with a built-in antenna of claim 1, 2 or 3, wherein the received frequency is within UHF band, and the tuner receives television signal.

30     5. The card with a built-in antenna of claim 4, wherein the electronic apparatus is a portable information terminal which is used as a television receiver.

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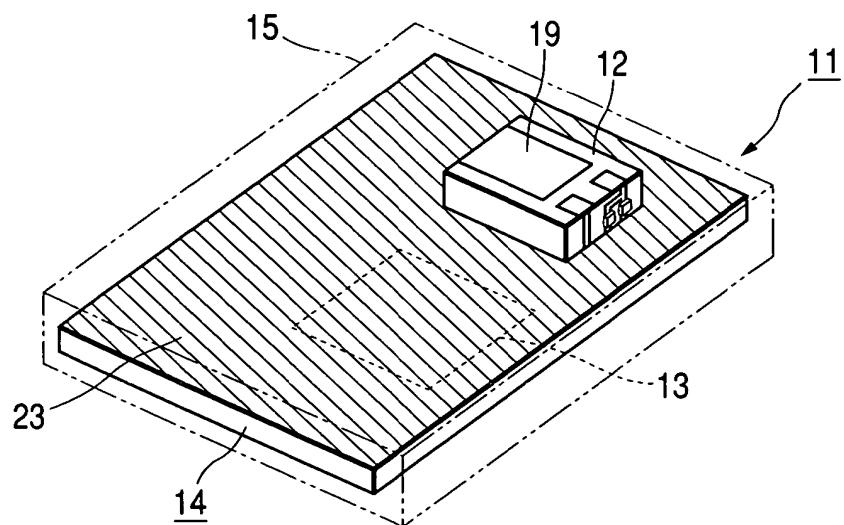
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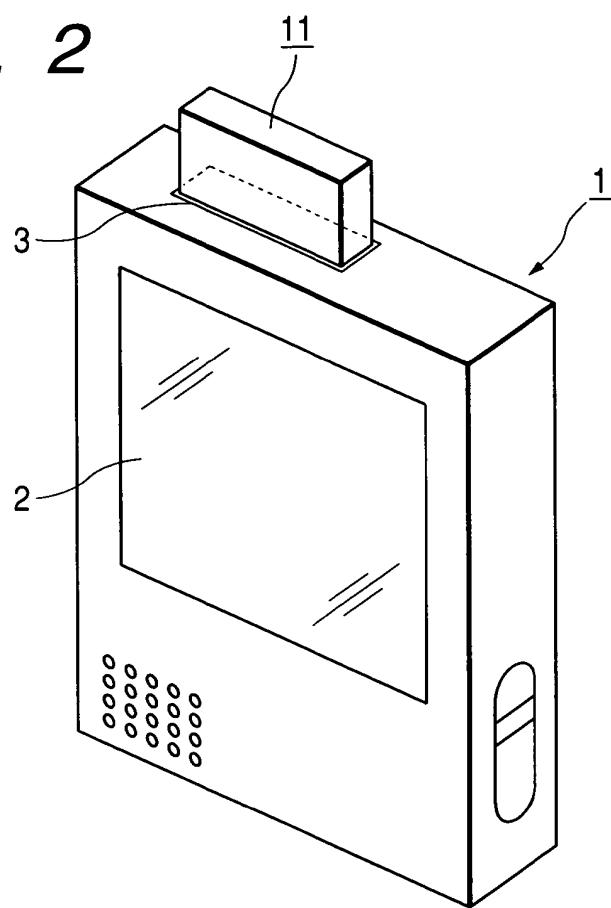
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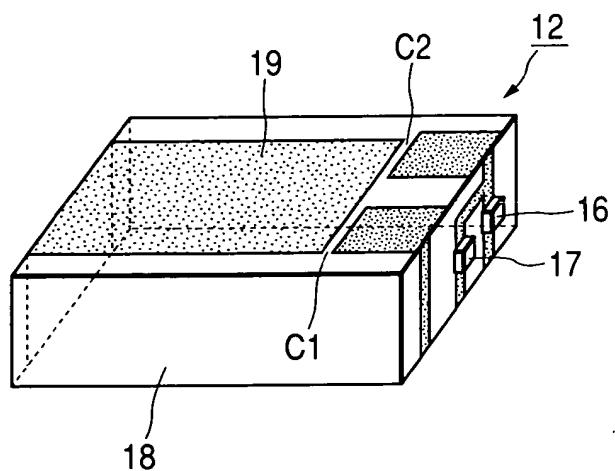
*FIG. 1*



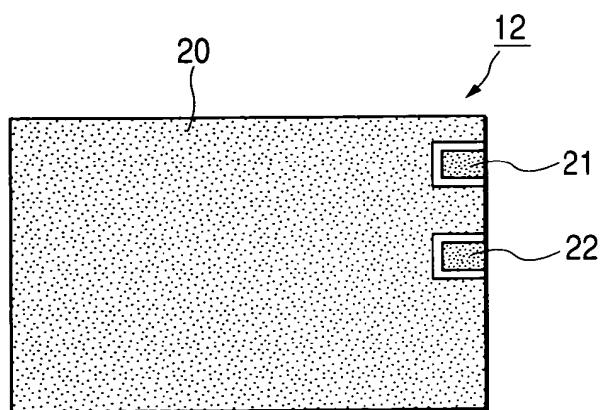
*FIG. 2*



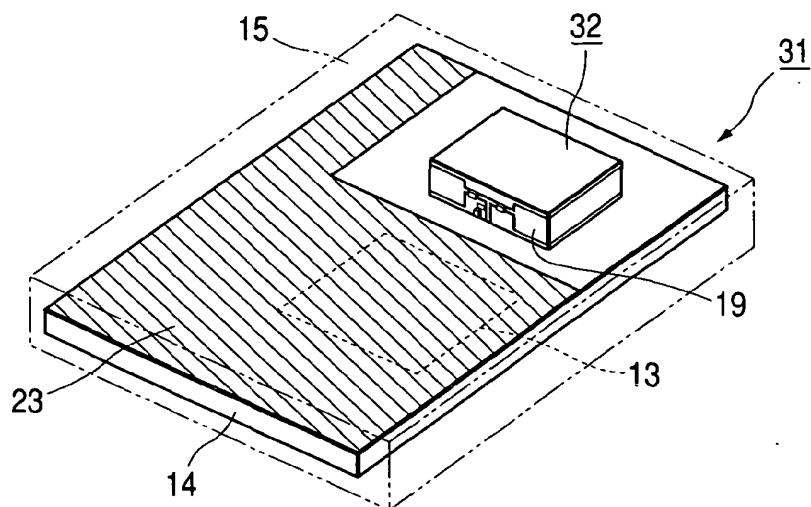
*FIG. 3*



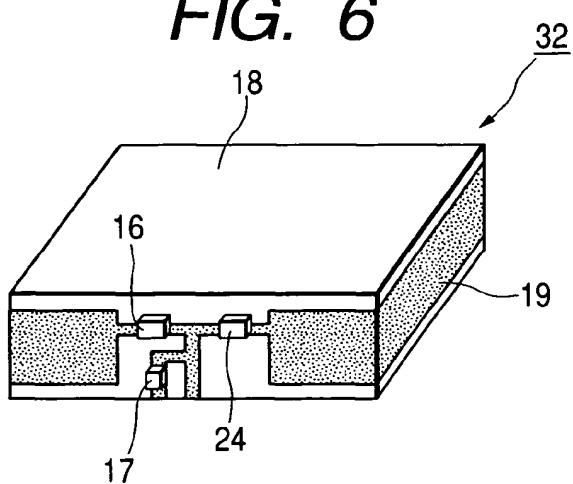
*FIG. 4*



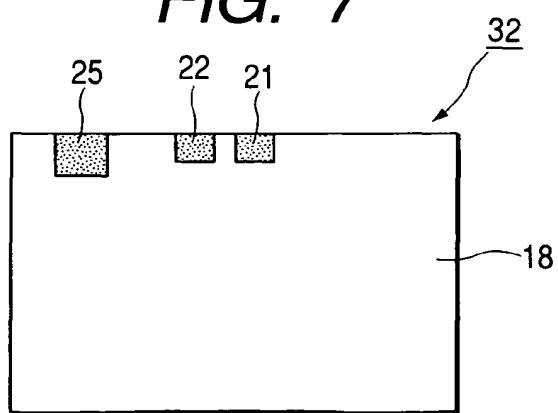
**FIG. 5**



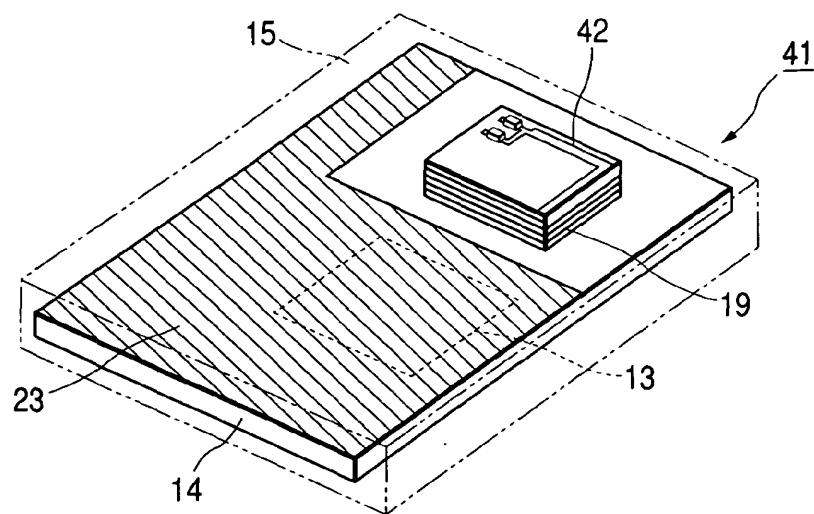
**FIG. 6**



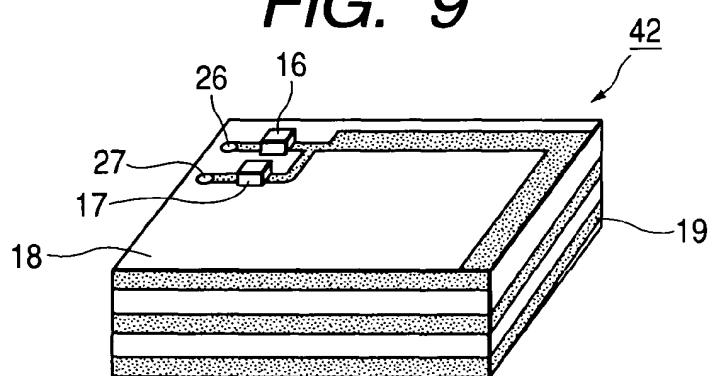
**FIG. 7**



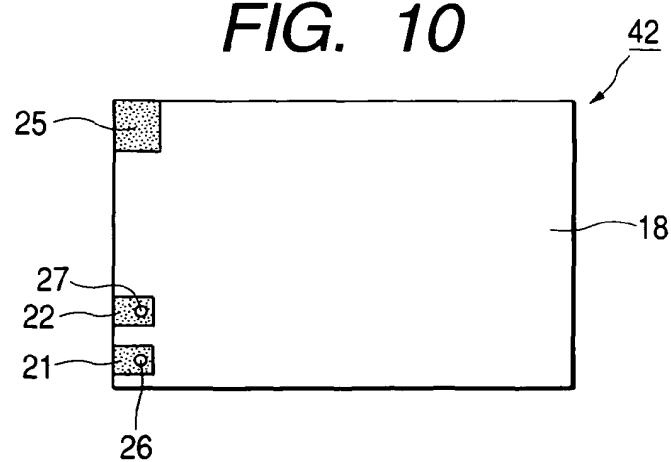
**FIG. 8**



**FIG. 9**



**FIG. 10**





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## EUROPEAN SEARCH REPORT

Application Number  
EP 04 00 8891

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US 6 396 454 B1 (DAVIS STEVEN J ET AL) 28 May 2002 (2002-05-28) * columns 4,5,7; figure 1 * -----	1,2,4,5	H01Q1/22
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A	EP 1 154 516 A (MITSUBISHI ELECTRIC CORP) 14 November 2001 (2001-11-14) * claims 1-20 * -----	1-5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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<p>The present search report has been drawn up for all claims</p>			
Place of search <b>The Hague</b>	Date of completion of the search <b>23 July 2004</b>	Examiner <b>Wattiaux, V</b>	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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EP 04 00 8891

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